



# Fukushima's Lasting Impacts on the Global Nuclear Industry

## *The Canadian Regulator's View*

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# Progression of the Accident

**14:46, March 11, 2011**

## Great East Japan Earthquake

Loss of off-site power, all operating reactors automatically shut down.





## Timeline of events

**Mar 11, 15:27-15:37**

Tsunami waves overwhelmed the tsunami barriers of Fukushima Daiichi nuclear power plant (NPP) site. Flooding primary and backup power systems and equipment, as well as the ultimate heat sink systems and structures of all six units on the site.



Fukushima Daiichi nuclear complex, March 11, 2011. (Photo: AP/Tokyo Electric Power Co.)



Compounding off-site power loss that occurred due to the earthquake damage to the transmission system. Resulted in the loss of on-site power sources (and/or on-site power distribution systems).





### Mar 11, 15:42

Station blackout declared. Units 1 – 5 of the Fukushima Daiichi NPP experienced extended station blackout (SBO) events, which exceeded 9 days in Units 1 and 2, and 14 days in Units 3 and 4.

### Mar 12-15, 2011

The nuclear units were unable to cope with the extended loss of electrical power and plant heat removal, and the reactors of Units 1, 2 and 3 suffered damage as the fuel overheated and melted. The reactor pressure vessels (RPVs) that enclose the reactor cores were eventually breached in those units, and radioactive material escaped from the reactors.



The radioactive material confined in the primary containment vessels (PCVs) was further released directly to the environment either in a controlled manner, i.e. by venting of the reactors' PCVs, or in an uncontrolled manner upon damage and failure of the confinement structures.

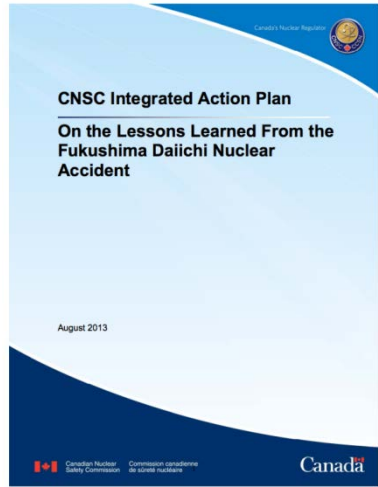


Fukushima Daiichi nuclear complex, Unit 4, March 24, 2011. (Photo: TEPCO)





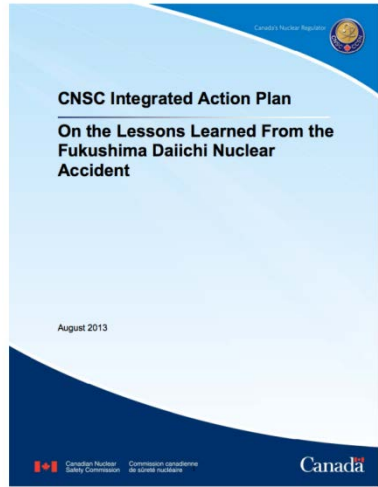
# Chronology



- Apr 2011**  
CNSC Task Force convened
- Jul 2011**  
Safety Review Criteria – Canadian 'Stress Test' issued
- Oct 2011**  
CNSC Task Force Report – Issued for public comment
- Dec 2011**  
IRRS Mission conducted
- Mar 2012**  
CNSC Staff Action Plan – Issued for public comment
- Apr 2012**  
External Advisory Committee Report issued
- Jun 2012**  
CNSC Action Plan – Approved by CNSC Commission
- Dec 2013**  
Short-term Actions completed



# Chronology



Dec 2014

Mid-term Actions completed



Dec 2015

Closure of CNSC Action Plan



## Reassessment of external hazard of higher magnitudes and consequences





# Post-Fukushima

## Safety Enhancements



# Post-Fukushima Safety Enhancements

- Reassessment of hazards
- Portable emergency equipment
- Enhanced control of hydrogen
- Emergency filtered venting
- Pre-distribution of potassium iodide pills
- Real-time radiation monitoring
- Exercise-Exercise-Exercise
- Stronger regulations
- Communications and public disclosure
- International involvement



# CNSC Action Plan



McMaster University  
Emergency Preparedness Exercise



International collaboration



CNSC ONLINE Extreme Event Simulation,  
Communications, and public education

## Shift in regulatory focus from accident prevention to accident prevention and mitigation



# Protect Fuel



Water Supply Connection Points



Bruce, Battery



OPG Flood Protection

## Licensee Met CNSC Requirements



# Prevent Severe Core Damage



Bruce Power Fire trucks provide cooling water. New emergency water pumping equipment procured and on site.



Darlington Emergency water supply.



Darlington Emergency portable pumps further strengthen emergency preparedness.

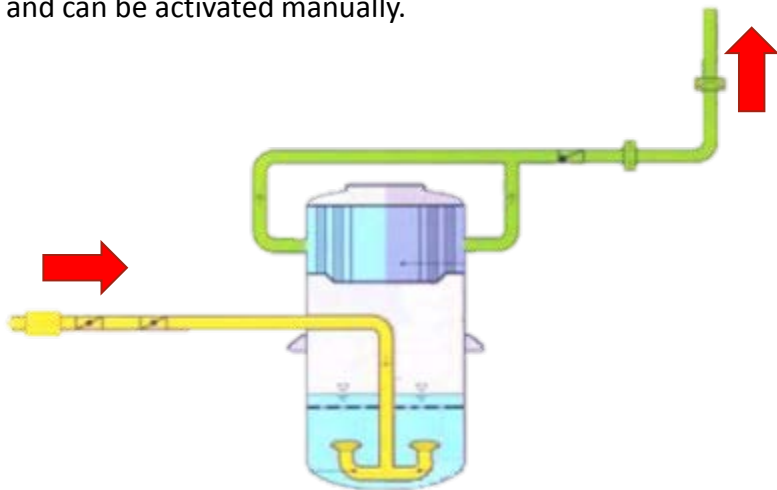
## Licensee Met CNSC Requirements



# Reactor Defence-in-Depth Protect Containment

## Emergency Containment Filtered Ventilation

The system is designed to provide additional filtering in case of a severe accident. It does not require power to function, and can be activated manually.



## Hydrogen Control and Mitigation

Passive Autocatalytic Recombiners (PARs) are designed to remove hydrogen in non-flammable atmospheres. Self starting it does not require power to function.





# Protect Containment



Point Lepreau Emergency filtered vent stack



Containment cooling enhancement to SAMG or through repowering Containment Air Coolers (plant specific approach based on design)



Hydrogen Control and Mitigation with licensees have enhanced hydrogen control through installation of Passive Autocatalytic Recombiners.

## Reactor Defence-in-Depth





# Protect Spent Fuel Pools



Bruce Power EME Drills



Point Lepreau , Crew Fuel Storage Tank Farm Drill



Permanent piping to spent fuel pool

## Licensee Met CNSC Requirements



# Enhancing Emergency Preparedness (Onsite)



Bruce Power New emergency response command and control facilities was demonstrated during Huron Challenge emergency exercise in Oct. 2012



OPG Command centre



McMaster (Research Reactor) Emergency Exercise

## Implemented Safety Enhancements



# Enhancing Emergency Preparedness (Offsite)



Evacuation and decontamination station



Potassium Iodine (KI) Pills



OPG

## Protecting the public through sheltering and evacuation



# Fukushima Lessons Learned

## CNSC played key role internationally

- IAEA Action Plan on Nuclear Safety
- Enhancing international peer review process
- IAEA Fukushima Report – DG lessons learned
- Enhanced accident prevention, improved mitigation of accident consequence, public protection



**Global safety is the responsibility of all stakeholders,  
government, independent regulators and industry**



# Convention on Nuclear Safety: The 7<sup>th</sup> Review Meeting

- Adopted in Vienna on June 17, 1994
- Aim of the Convention is to legally commit participating States operating nuclear power plants to maintain a high level of safety
- As president of the 7<sup>th</sup> Review Meeting, I am committed:
  - to supporting strong review processes that achieve tangible improvements in nuclear safety



# Canada's Global Efforts Post-Fukushima

## Risk Communications and Perceptions Workshop

- Hosted by the CNSC in November 2016
- Included eight municipal, provincial, federal and international partners
- Keynote speakers were Dr. Makiko Orita, a public health nurse, and Professor Noboru Takamura from Nagasaki University's Atomic Bomb Disease Institute







# Fukushima Impacts on the Nuclear Industry

- Public perception
  - Demands for transparency, information, engagement
- Reconsideration of energy mixes
  - Some countries are quitting or scaling back nuclear
  - Others are continuing or increasing their nuclear portfolio
- Enhancement to nuclear safety from improvement initiatives
- Small modular reactors gaining attention





# Continuous Improvement From Other Events

**CNSC learns lessons from all  
sectors, not just nuclear**



# Root Cause Findings

## Lac Mégantic (July 6, 2013)

- Inadequate regulatory oversight
- Inadequate awareness / monitoring of regional activities
- Inadequate follow-up on safety-related deficiencies





# Root Cause Findings

## Mount Polley (August 4, 2014)

- Dam built on undetected weak layer of glacial deposits
- Updating required for design, monitoring and regulation of tailings dams in British Columbia





# Conclusions for the CNSC

- Shift in regulatory focus from accident prevention to **accident prevention and mitigation**
- Continuous improvement from other events
  - Learn lessons from all sectors, not just nuclear

**No room for complacency!**



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